Working Group 3 Report

Engineering Designs for Remote Operations

Issues of Design & Expert Support for Design, Commissioning, Sustaining Engineering

Main Participants

- R. Bacher DESY
- H-J Eckoldt DESY
- R. Larsen SLAC, Convener
- D. Rice Cornell
- E. Siskind NYCB
- J. Skelly BNL, Co-Convener
- K. White JLAB
- F. Willeke DESY
- +a number of drop-in guests for short periods

Charge

- Examine *Remote Operation* of hardware subsystems.
- Will present systems perform *well enough* with experts *not present* on site?
- What additional design features need to be built in? (i.e. to minimize experts on site).
- What level of engineering expertise *is* necessary on site…?

Technical Issues

- Reliability/ Availability
  - Design for both
- Standards - Hardware
  - Modularity, rapid exchange, redundancy
- Standards – Software
  - Standard Interface, Self-Identifying Devices

Personnel Issues

- Expert Roles & Requirements
- On-Site Requirements
- Retention of Key Personnel

Reliability/ Availability

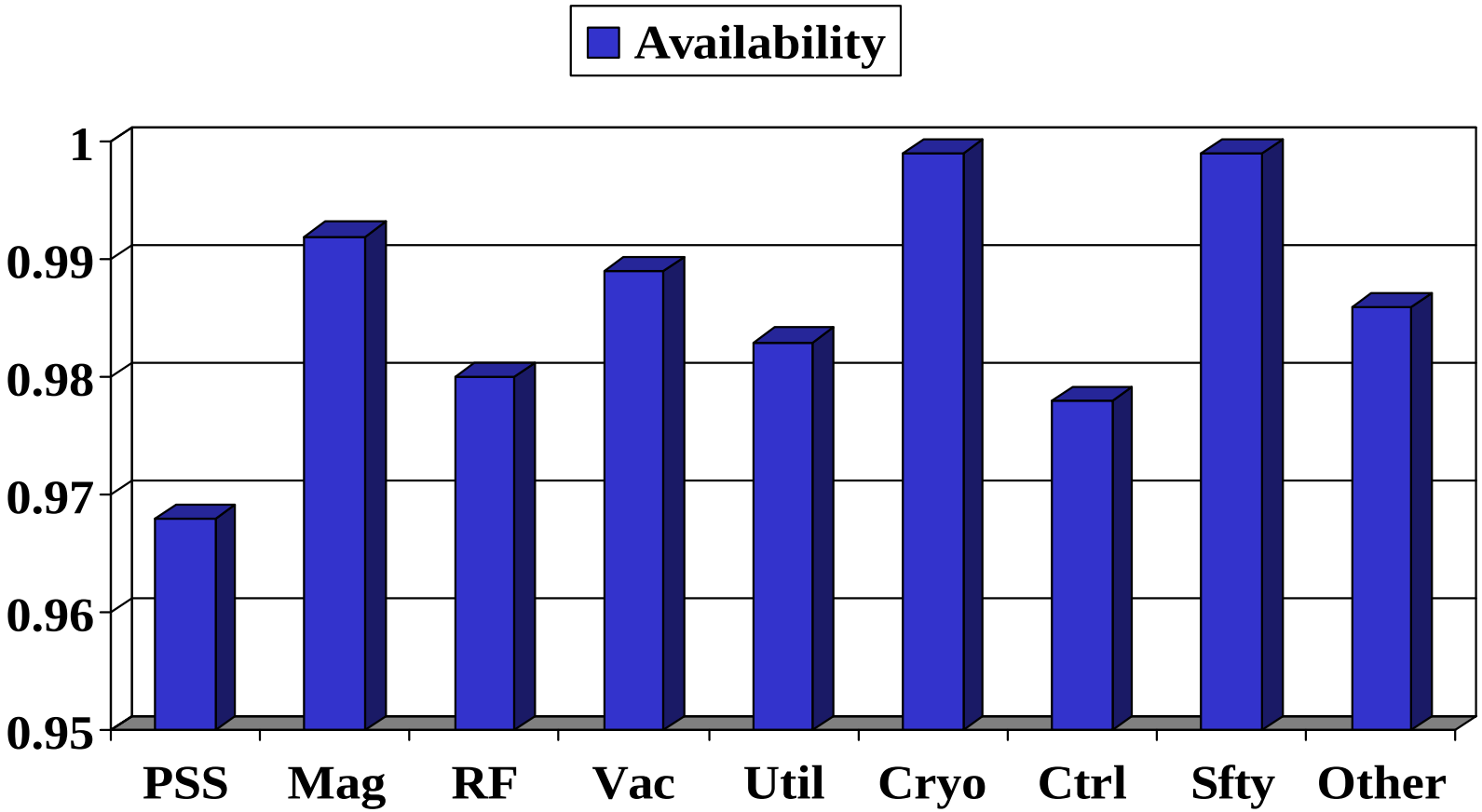
- Charge is focused on technical feasibility of remote operations with *few* experts on site.
- What is *"good enough"* machine performance?
- Studies of current machines appear to show that *Availability* is achieved by:
  - Adding redundancy to critical systems.
  - Keeping experts on hand to trouble-shoot system problems.
  - Systematic Engineering Upgrade programs.
  - Assigning top priority for all engineering personnel in laboratory to achieving high availability (Luminosity) for the operating machines.

Designing for Availability

Summary of Several Availability Studies
& Design Implications for LC Systems

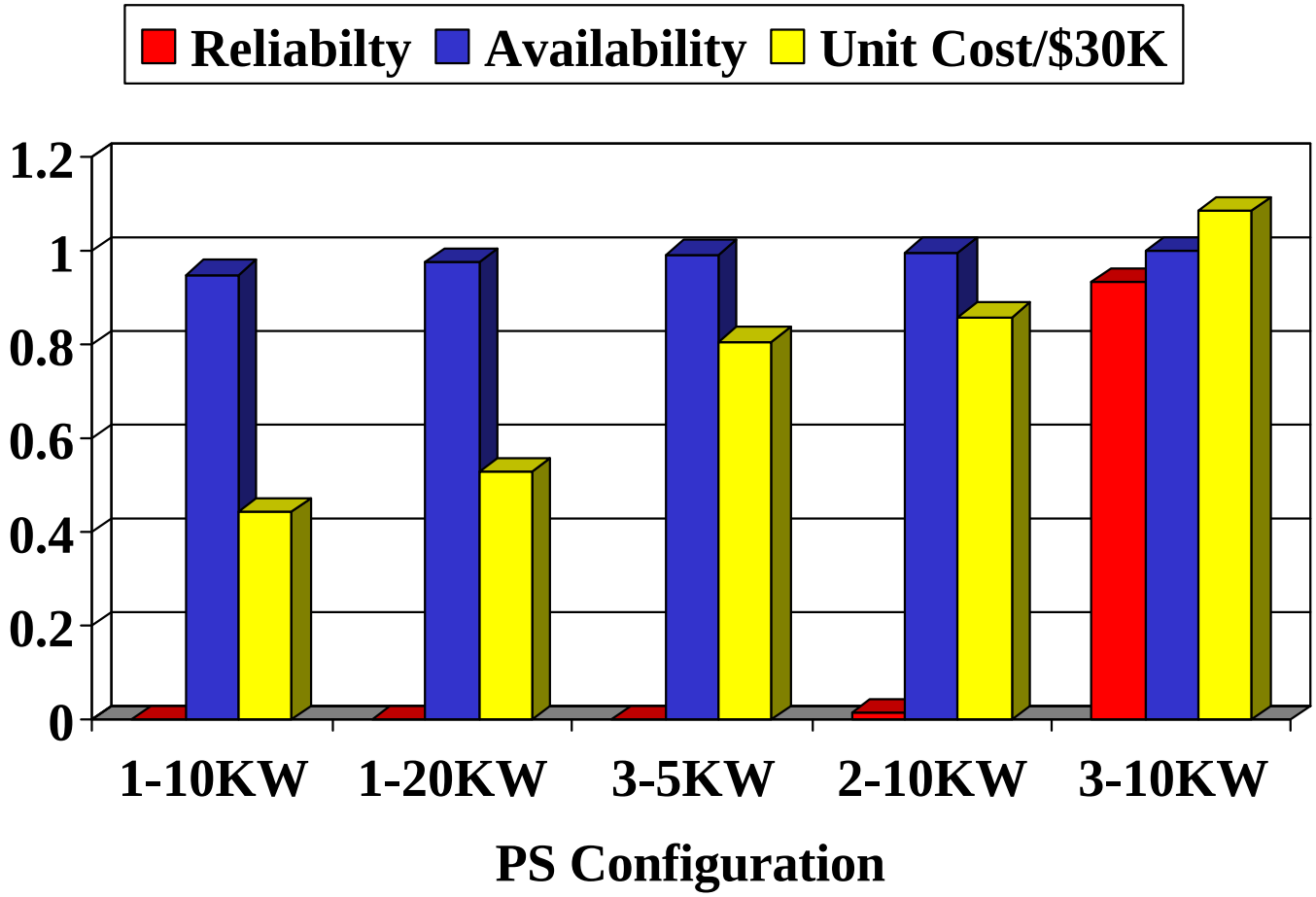
- **R. S. Larsen**
- Remote Operations Workshop
- Shelter Island NY
- September 17-20 2002

PEPII System Availability 00-01



10kW 1500 PSS Configuration Example

Mission Time 6575 Hrs. MTTR 2 Hrs. *[Ref. P. Bellomo]*



Machine Availability

1. System Availability Model in NLC Zeroth Order Design Report (ZDR), May 1996, J. Sheppard et al

2. Power Supply Systems Studies, P. Bellomo et al, J. deLamare, 1999-2002

3. LC Power Supply System Availability Estimated from Measured Data for SLAC Machines, S. Rhee & C. Spencer, Sept 2002

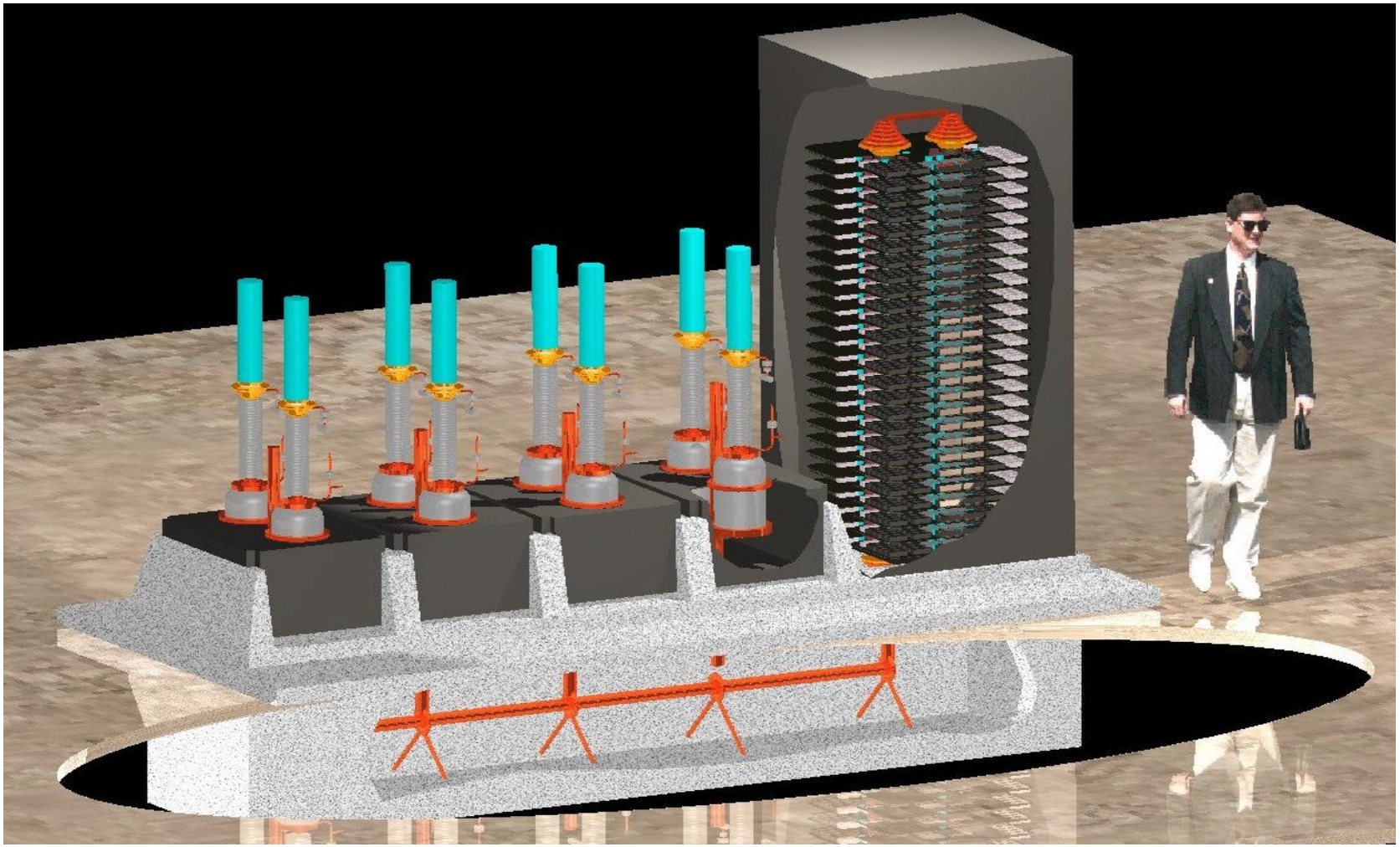
4. SLC Modulator Upgrades, A.R. Donaldson, 1992-1999

5. Estimated Availability Solid State 8-Pack Modulator System, Z. Wilson, 1999

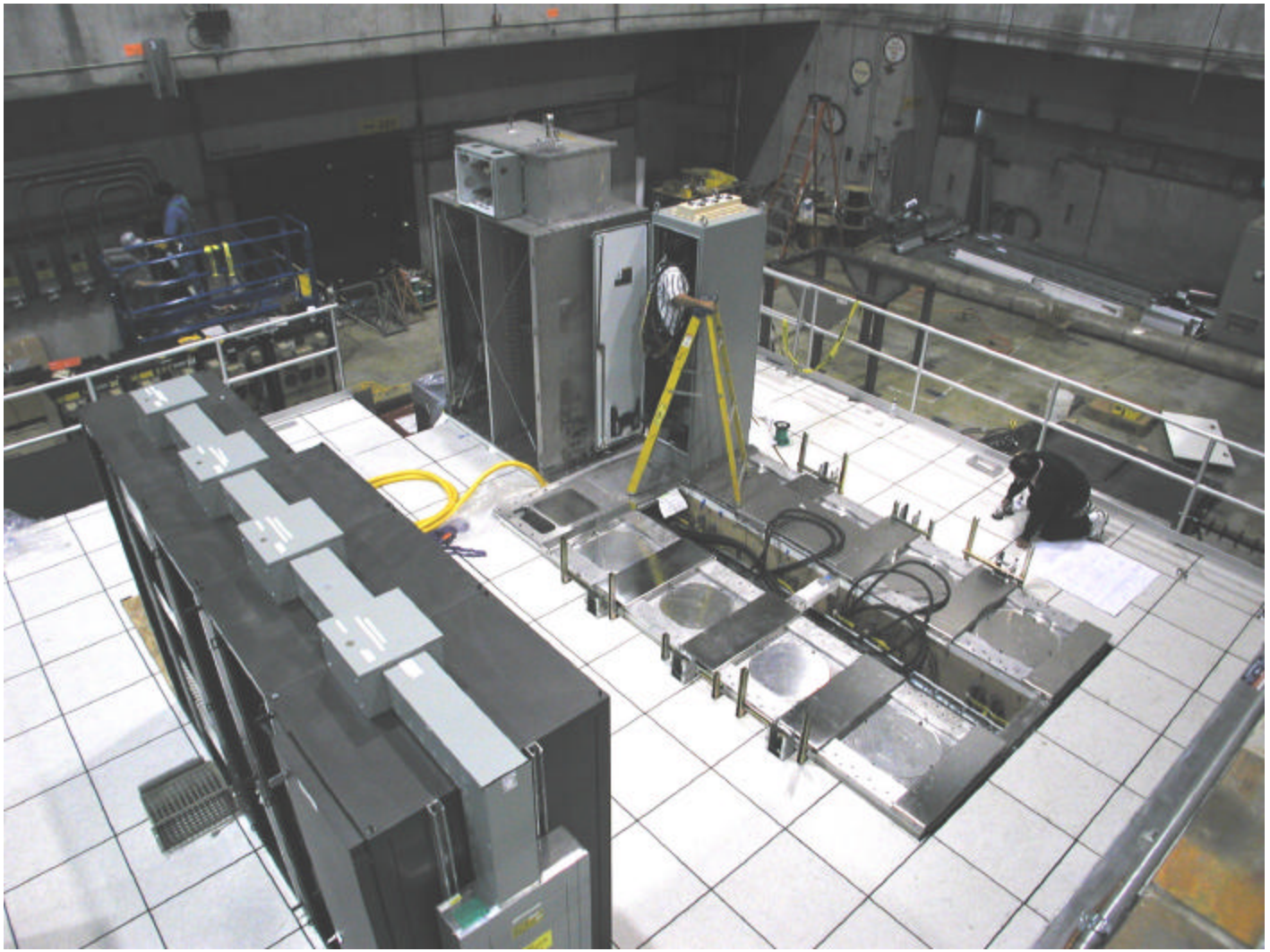
Availability Studies

- Conclude that Availability figures for current systems fall significantly below that needed to meet advertised figures for NLC (85%).
- Availability goals and rationale need a fresh look.
- Improvements must be made through combination of improved reliability, redundancy and reduction of MTTR.
- Has large engineering impact for LC.
- Full set of slides will be posted on Workshop website.

8-Pack Solid State Modulator Concept

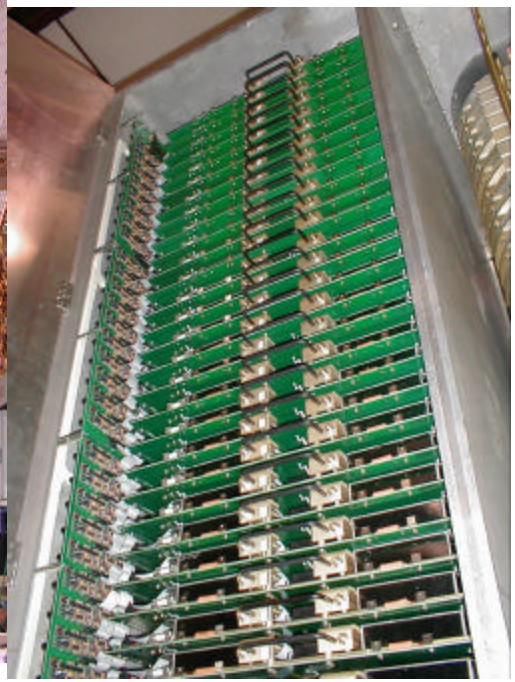


8-Pack Under Assembly



8-Pack Prototype 500kV 2000A Pk

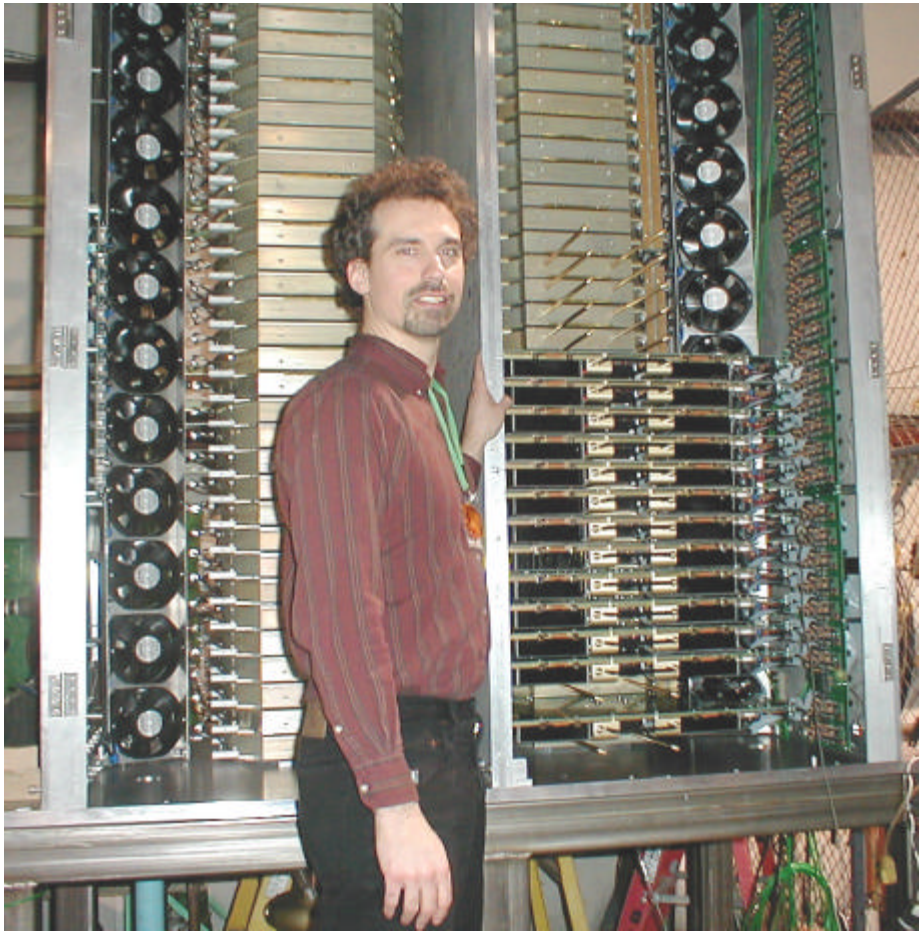
Shown set up to run 3-5045 S-Band Diodes + Water Load



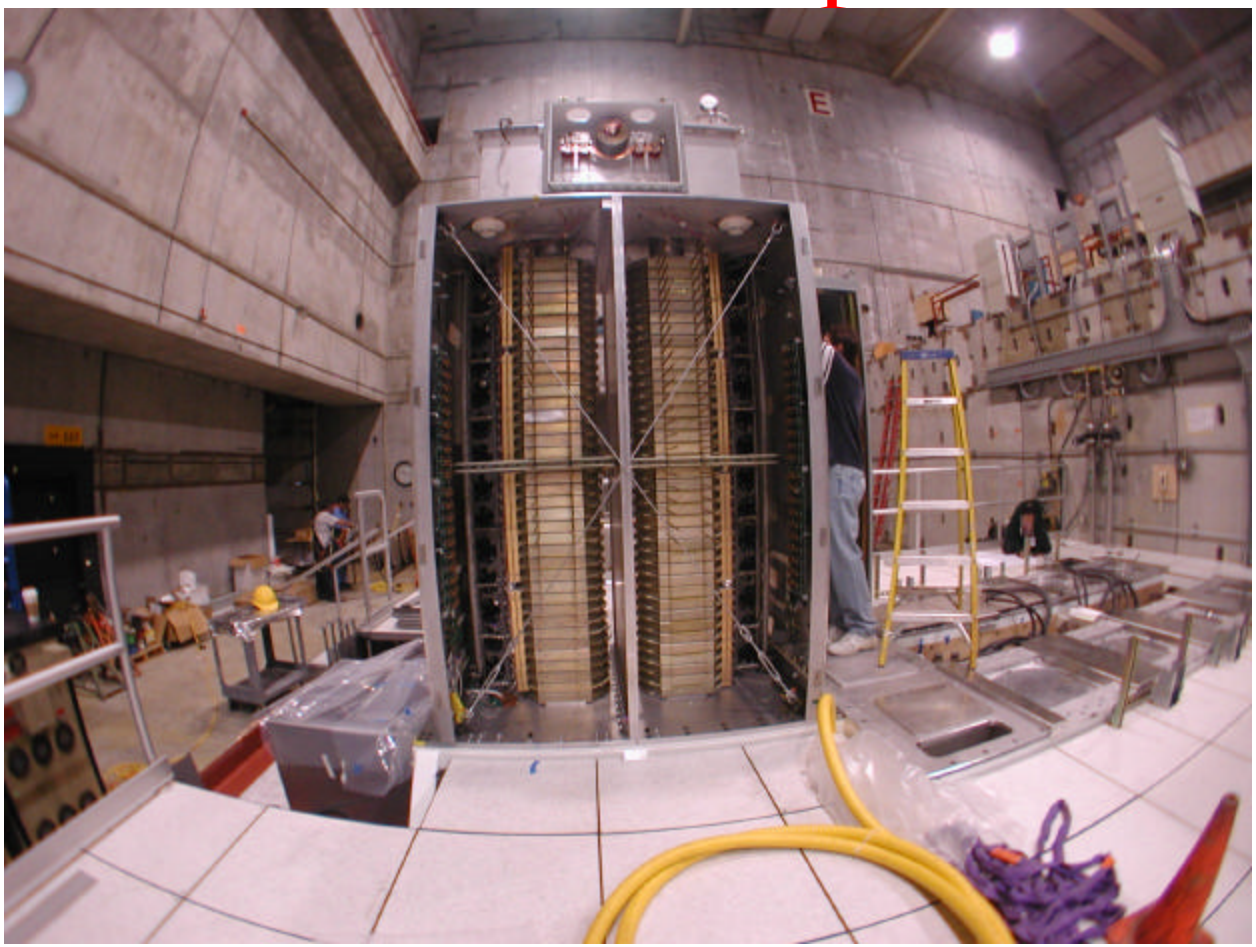
8-Pack 500kW 5kVDC Supply

IGBT Driver Board Construction

Core Stack & 1:3-Turn



SS Core Stack Newly Installed in 8-Pack Complex



SS Modulator Availability

- In principle, SS stack could operate over full mission of 6575 hours without intervention.
- Modular design makes MTTR board swapping <<2 Hrs.
- System operates at low voltage (5kV max) unlike present units 40 kV or more.
- Weakest point in terms of MTBF is the large DC power supply.
- Need to create modular design for quick repair of the 500 kW PS.

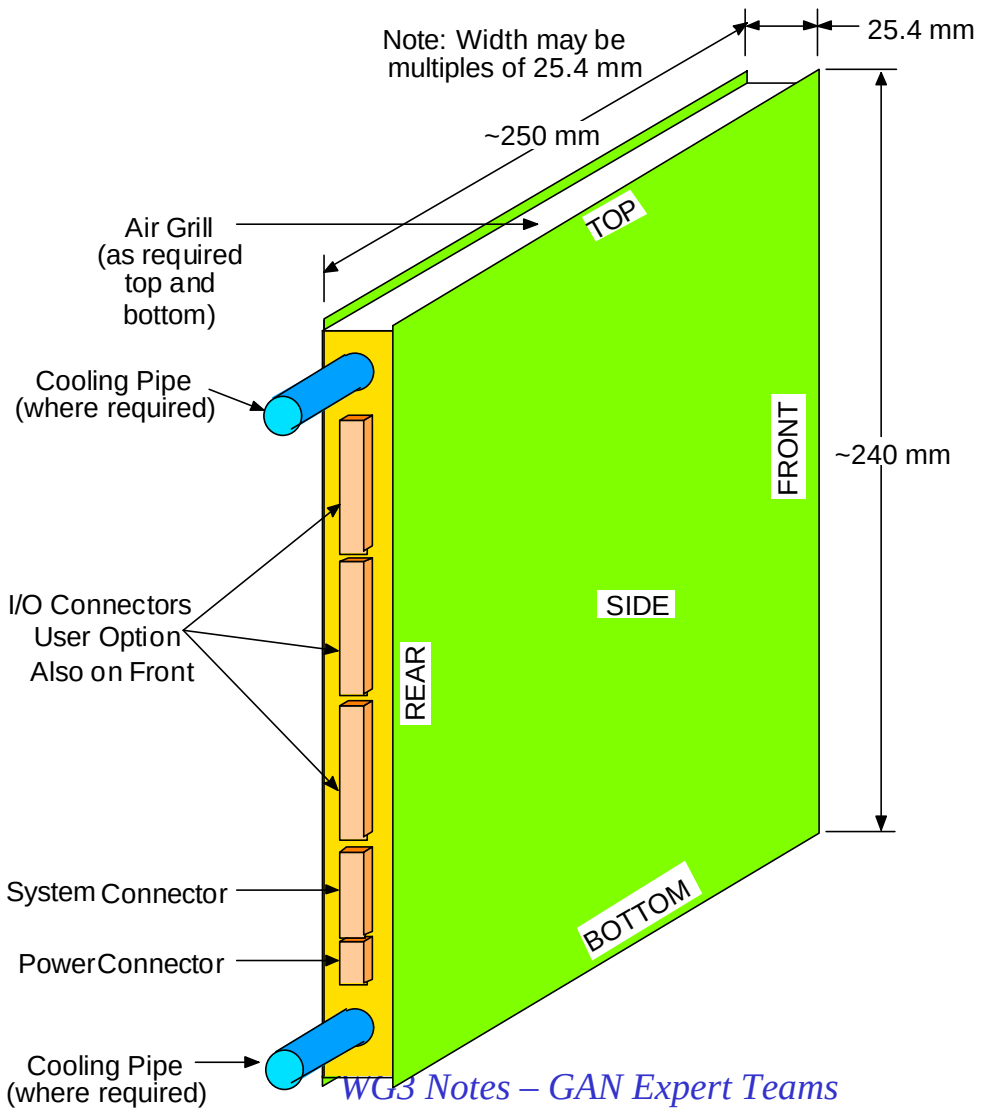
GAN WG3 Discussion: Wed. 091802

- Role of Diagnostics
  - What diagnostics should be added that would be necessary to a remote GAN operator or expert?
    - Remote expert should have access to history files of all recent data for any part of the machine that is monitored. Ref. Siskind paper on real-time needs for front end controls architecture.
    - Different SYSTEM experts in remote locations should access data for their own systems on a regular operations schedule.
    - Fast fault data as well as archived data from DAQ streaming memory should be available remotely (NOT in real time).
  - What diagnostics should be added independent of Specific needs for GAN?
    - Better diagnostics for internals of power supplies, esp. pulsed power, pulsed Rf and pulsed instrumentation, including transient digitization of video pulse amplitude and phase.
    - Additional remotely accessible diagnostics from any instruments or power sources in tunnels.

GAN WG3 Discussion: Wed. 091802

- Standard Instrument Modules
  - Traditional modules with backplanes are no longer viable for high density intelligent instruments.
  - Reasons: Backplane coupling and required speeds, lack of voltage and bandwidth flexibility, are inadequate.
  - Solution: VME Standards Organization (VSO) working on new modular standard
    - Eurocard format
    - 48VDC in back with on-board DC-DC converters for 5, 3.3 & 1.5V as needed
    - Fiber optic or copper serial IO
    - Input signal connectors in front or back
  - GAN should collaborate on this standard for high performance instrument modules for beam instrumentation and other DAQ needs. Would interface to controls via high noise immunity serial protocols proposed by Siskind.

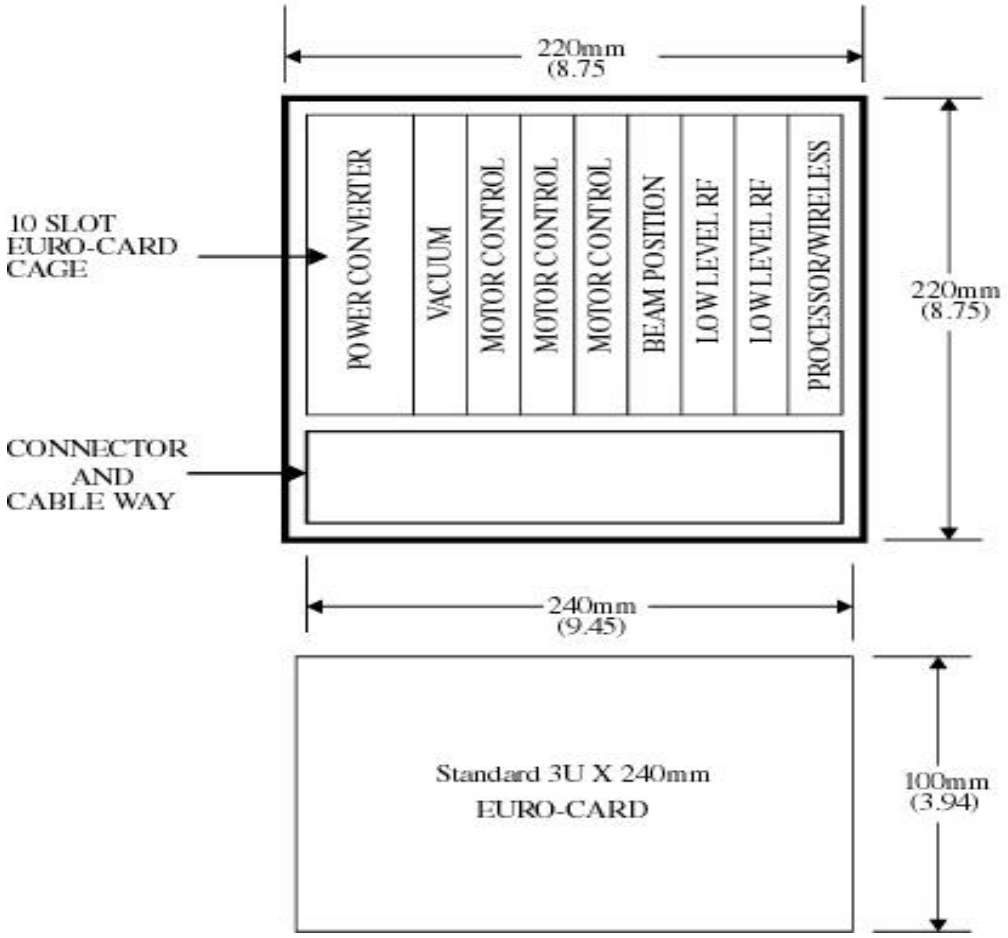
The VSO Concept



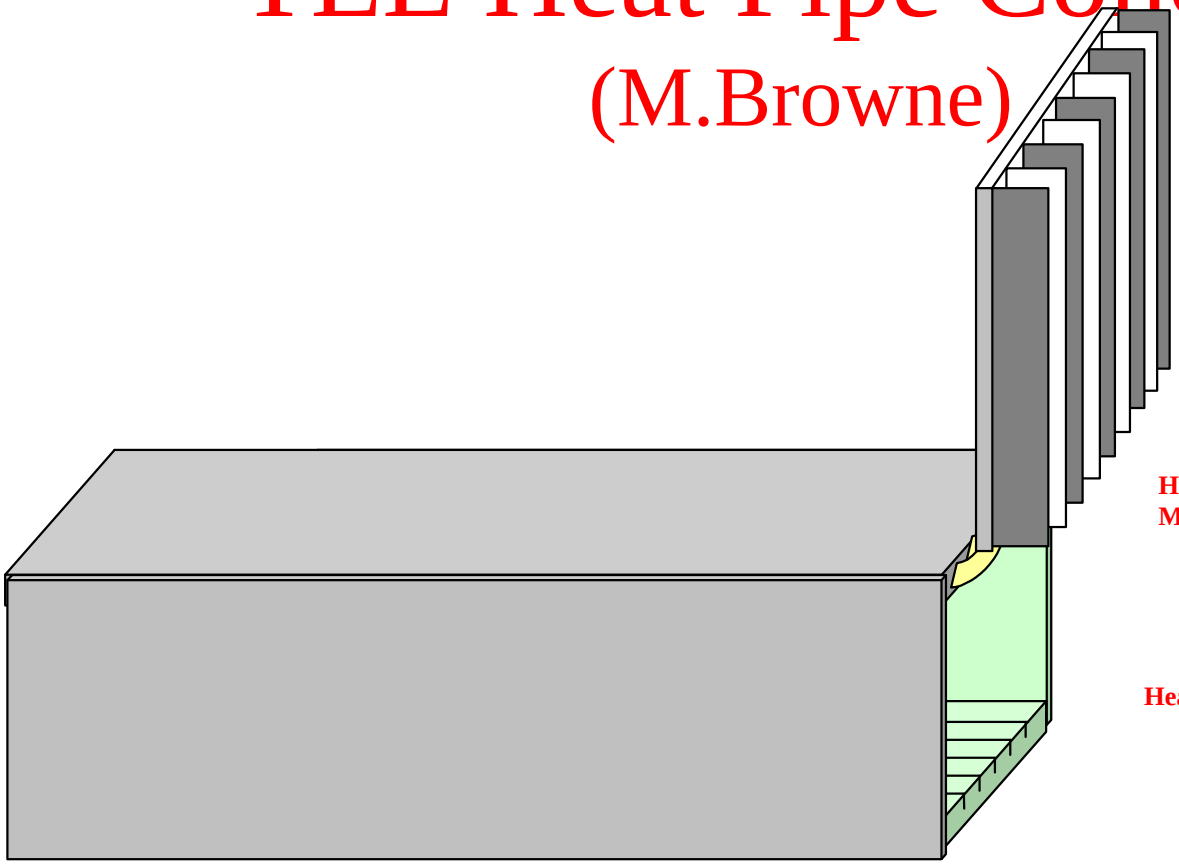
GAN WG3 Discussion: Wed. 091802

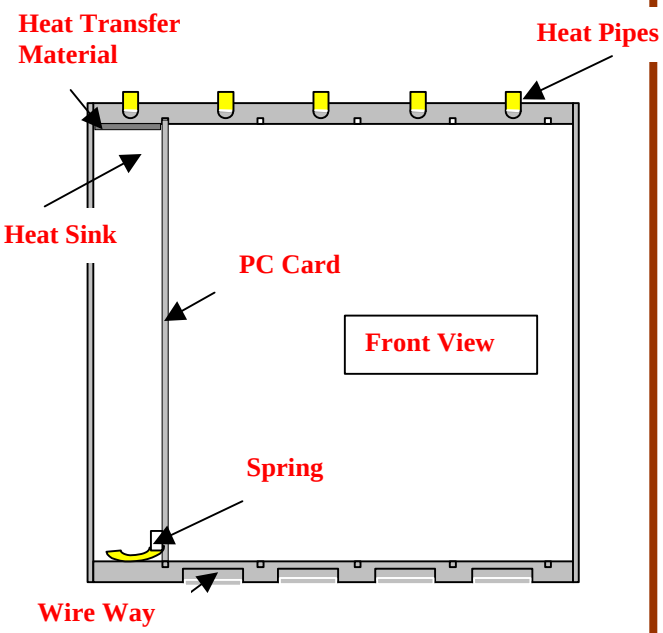
- Tunnel Electronics Instrumentation (morning)
  - Reviewed tunnel instrumentation concept studied at SLAC
  - In-tunnel electronics in mini-crate in tunnel walls for radiation protection for COTS electronics (Comm'l Off The Shelf)
  - Radiation modeling indicates COTS will survive.
  - Vacuum pump supplies a separate system with 48-5000V converter mounted near beamline and preferably right on Rf vacion pumps.
  - Other instruments include BPMs, Magnet Movers, LLRF, Temp.

Proposed Tunnel Electronics Enclosure (TEE) for Front End Electronics (FEE)

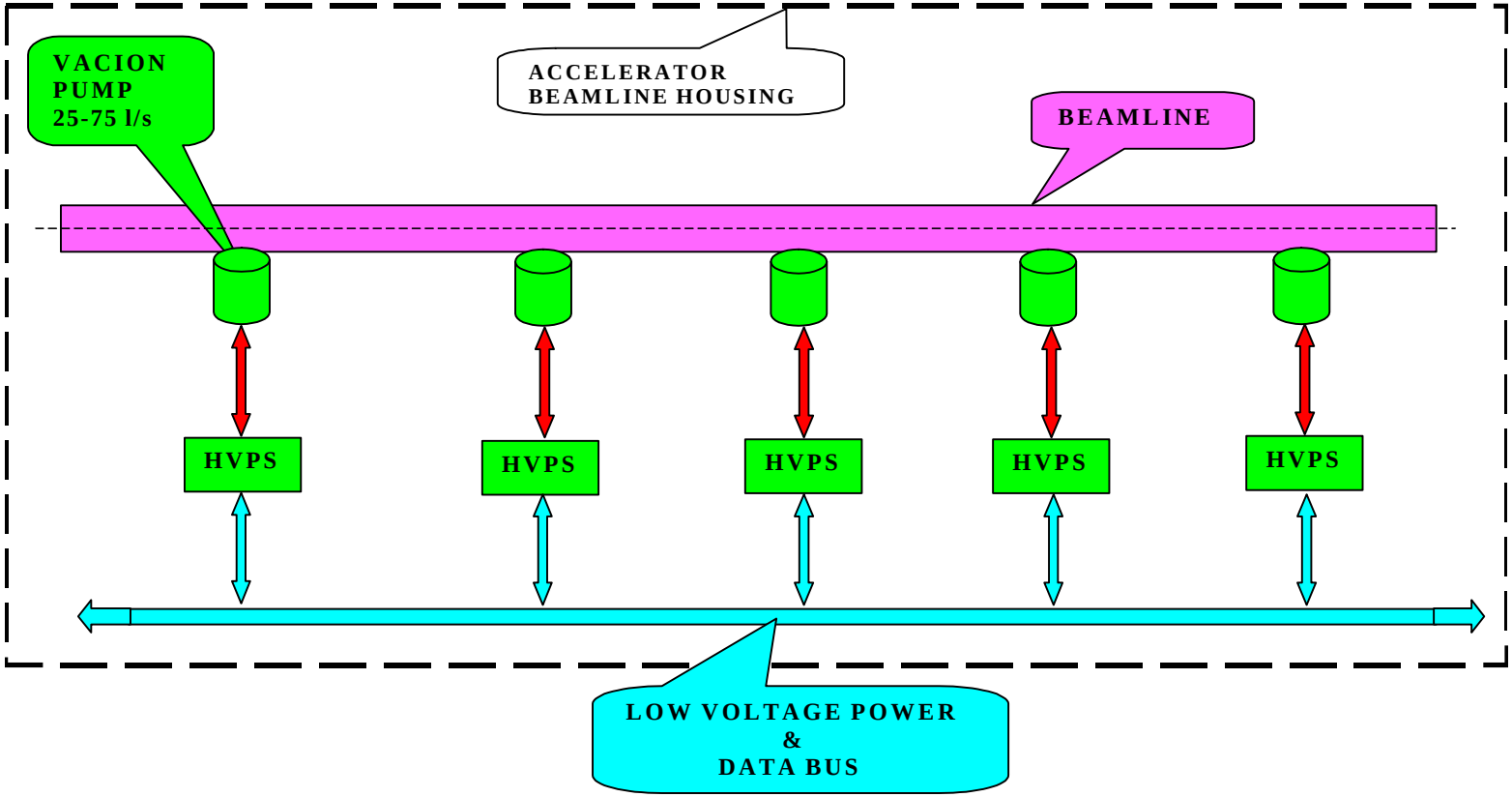


TEE Heat Pipe Concept
(M.Browne)

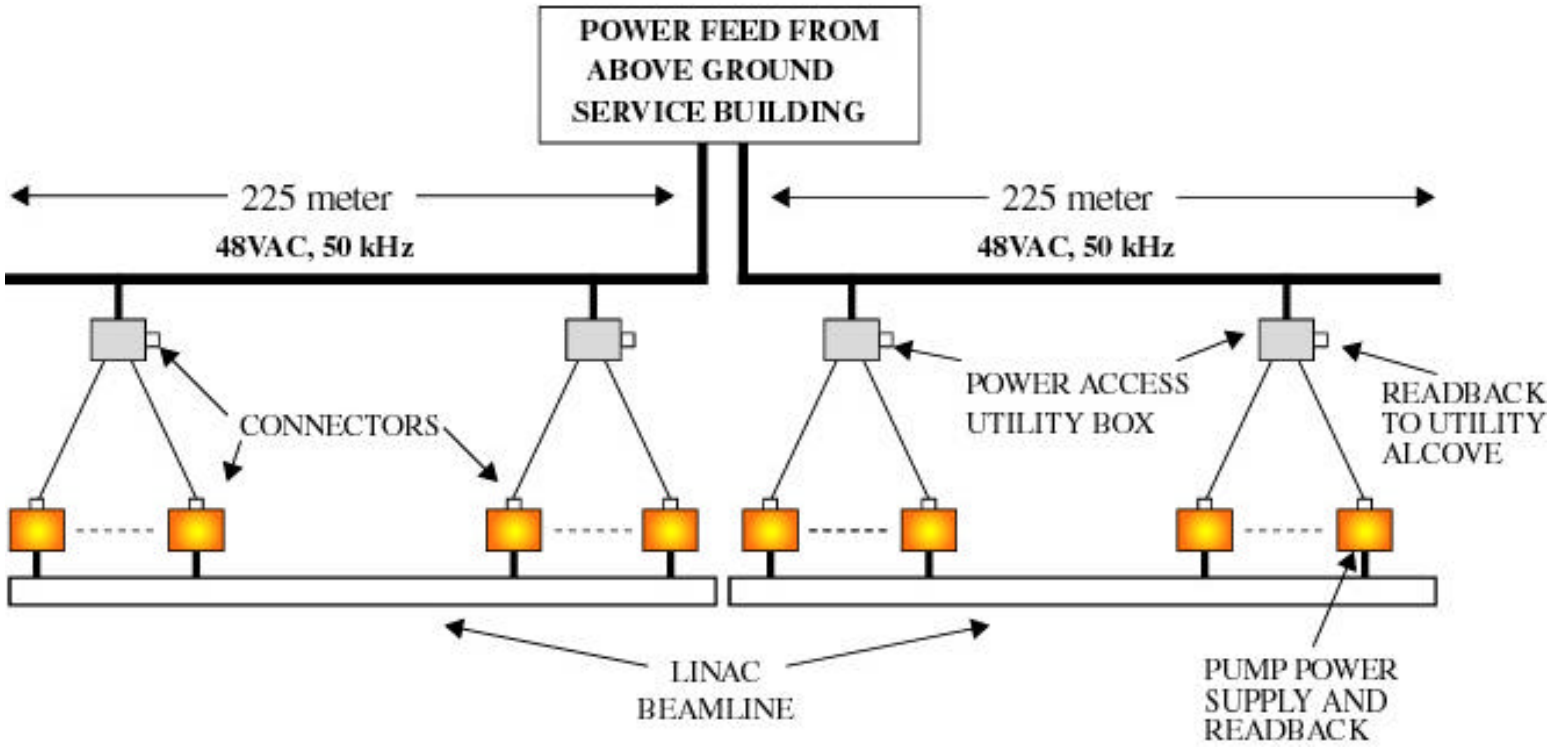




NLC Vacuum Electronics
PSOAP R&D Proposal



Proposed Vacuum Pump Power Distribution



GAN WG3 Discussion: Wed. 091802

- E. Siskind , NYCB – Noise-tolerant Streaming Real-time Data Acquisition Fabric For Pulsed Accelerators
  - Discussion of R&D aimed at implementing imbedded noise immune fiber network protocols for connecting hardware at remote nodes.
  - Beginning test phase of hardware to replace Multibus in SLAC accelerator.
- R. Bacher, DESY- Thoughts about remote operation in a Global Accelerator Network
  - Model of expert personnel requirements for GAN-based LC.
  - Discussed personnel at remote engineering sites, host accelerator site and remote control room through phases of design, commissioning & maintenance (error handling).
  - Discussed skill levels of various participants.
  - Discussed philosophy, common quality standards.
  - Estimated staff at <100 for 24/7 coverage of on-site maintenance and operations.

GAN WG3 Discussion: Wed. 091802

- J. Skelly- PSC and PI for fiber-linked PS for SNS
  - General purpose 16 bit ADC PSC with 6 channels
  - Each channel 4 analog channels 16bits, 15 bit command
  - No special diagnostics; these would be imbedded in target devices and interfaced via PI.
  - IOC at top contains intelligence for data transfer to control system.
- Hans-Jeorg Eckholdt- DESY TTF2 Power Supplies
  - New supplies for SC quads and correctors
  - Reside in tunnels
  - Redundant 4/5 systems
  - Modular for quick replacement
  - Separate diagnostics ports, one for engineering web-accessible
  - Quick disconnect “docking port” for entire rack assembly (“container”) transported and installed via monorail
  - Radiation protection concrete shield blocks recently added.

GAN Expert Requirements 091902

- Basic Assumptions
  - Each Collaborating institution responsible for building a System also accepts the responsibility to provide long-term expert support.
  - Experts are available through Commissioning into Operations (Sustaining Engineering phase).
  - Expert persons are appointed from the original design team, or from specially trained people, to fill this role.
  - The Collaborator agrees to maintain competent persons in the role as long as they are needed.
  - If Collaborator is unable to fulfill this role for any reason, the Full Collaboration must find an alternate solution.

GAN Expert Requirements 091902

- Phases
  - Design
  - Manufacture
  - Installation
  - System Integration & Commissioning
  - Operations
  - Sustaining Engineering
  - Maintenance- Hardware/Firmware & Software
- Types of Experts In Phases
  - Engineers (EE,SWE,ME,RF,EngP,CE,IE(Manufacturing) etc
  - Engineering Hdwe & Swe Designers
  - Engineering Coordinators
  - Engineering Technicians
  - Maintenance Technicians
  - Machine Physicists (System Physicist)
  - Machine Engineers (Systems Engineers)
  - Chief Operators, Operators

GAN Expert Requirements 091902

- Definitions & Duties of GAN Teams
  - Design
    - Engineers, designers, technicians, tech writers
    - Design, prototype, test, document all system components
    - Adhere to requirements and established standards
    - Design for modularity, reliability, maintainability
    - Assist with manufacturing documentation for bid packages
    - Assist with technical descriptions and maintenance training materials with appropriate groups
  - Manufacture
    - Industrial Engineers, Coordinators
    - Develop manufacturing plan for each element of system
    - Develop instructions with design team for on-site testing
    - Develop schedules
    - Develop contracts & oversee all manufacturing phases to completion

GAN Expert Teams

- Installation
  - Industrial Engineers, Coordinators
  - Develop installation plan for each element of system
  - Develop installation documentation, instructions for all participants
  - Develop contracts & oversee all installation phases to completion
- System Integration & Commissioning
  - Systems Engineers, Coordinators, Technicians
  - Develop System Integration & Commissioning plan for all systems interfaces
  - Coordinate with all Installation teams
  - Develop schedules and work plans for all participants
  - Develop contracts as necessary & oversee all integration/ commissioning phases to completion

GAN Expert Teams

- Operations
  - Duty Machine Physicist/ Engineer, Duty Chief Operator, Duty Machine Operators, On-Call Systems Experts, On-site System Maintenance Technicians.
  - Operations management develops Operations Plan & ***Operations Responsibility Plan*** for all participants
  - Staff Operations Team on 24/7 basis.
  - Develop experimental support, machine maintenance and machine development plans.
  - Coordinate all machine-related activities.

GAN Expert Teams

- Sustaining Engineering
  - Systems Engineers provide first line of oversight of all systems
  - Systems Coordinators provide field support for all system documentation
  - SE teams coordinate with responsible management to monitor machine performance, develop strategies for improvements, propose improvements, obtain assistance from design teams in executing improvement programs.
  - SE assumes project management role for improvement projects, or assigns role to others.

GAN Expert Teams

- Maintenance- Hardware/Firmware & Software
  - Maintenance Engineers, Network/System Administrators, Coordinators, Technicians
  - Develop and execute maintenance plans for 24/7 operations
  - Develop and implement training regimen, safety oversight for all participants, in collaboration with System design groups.
  - Coordinate closely with Operations Team on daily basis.
  - Log ALL activities
  - Coordinate with responsible SE's and Design Teams to execute machine special repairs, improvements and upgrade programs.
  - Suggest and help develop maintenance documentation and on-line tools for maintenance staff.

Site Safety (ES&H)

- ES&H is responsible for the site including the Site Safety Office, Radiation Safety, Electrical Safety etc.
- Essential ES&H functions are assumed to be on-site.
- Analysis of needs was not attempted. Numbers could be significant because of both safety and security concerns.

GAN Expert Teams - Observations

- Only participants who *must* be on site at all times are Maintenance Team, Site Safety Staff and appropriate liaison personnel for Remote Operations and Engineering.
- Operations Team & On-Call Team for a given series of shifts can be drawn from multiple physical locations as desired.
- Sound management dictates that lines of authority be with the assigned Operations Team, and lines of support responsibility be with assigned Systems Teams who provide the On-Call experts for 24/7 coverage.
- *All critical backup positions should be covered by at least two On-Call Experts per shift.*

Issue: Retention of Expert Personnel

- ***THE FOLLOWING COMMENTS ON KEY PERSONNEL APPLY INDEPENDENT OF "COUNTRY OF ORIGIN." SPECIFIC IMPLEMENTATIONS <u>WILL</u> DEPEND UPON COUNTRY AND LOCAL PRACTICES OF COLLABORATOR.***
- Design, Commissioning, Sustaining Engineering Phases
  - What can be done to maintain the involvement of key personnel who are (a) On Call on occasional basis (b) Underutilized when machines are running well?
- Maintaining high quality and challenging roles for
  - Engineering personnel
  - Maintenance personnel
  - Operations personnel

Engineering Personnel

- Need to be able to articulate career path for new young engineers for all disciplines.
- Need to hire appropriate mix of personnel for range of tasks
- Peak design activity will taper and begin transition.
- Some but not all will migrate to further roles within organization including transfer to new projects, upgrades, sustaining engineering.
- Career paths in laboratory that require engineering responsibility extending to installed systems should be spelled out with terms revisited on annual basis.
- Net engineering task mix must offer significant opportunities for continuing intellectually challenging work.
- Management must be even-handed and inclusive with assignments for talented key staff– i.e. no elite groups that are “more equal than others.”

Maintenance Personnel

- Goal is a Coordinated System Maintenance Team for all systems on machine.
- On-Site management must establish the maintenance plan and execution. This requires engineering leadership, and interaction with all responsible Systems Teams for materials support, face-to-face training etc.
- Coordination should be led by resident Maintenance Engineer(s) in concert with Operations Team.
- Maintenance people should be trained in systems level diagnostics usage and should cross-train on closely related systems.
- Need to aim for high level of systems capability, and to train maintenance personnel for new career growth opportunities.
- Career path for maintenance people, besides management role, should include developing Project and R&D support skills.
- Maintenance tools need to be continually developed and upgraded.

Operations Personnel

- Operations
  - Operator career paths currently are not as attractive as engineering or technician disciplines with more technical backgrounds e.g. due to shift work.
  - Career paths should be established which are intellectually challenging. (Playing on the Web in "spare time" is not a productive career path!)
  - Opportunities should be developed for operators to
    - Perform some fraction of project work other than On-Shift
    - Advance technical and/or managerial education
    - Advance in Operations roles
    - Migrate to more technical roles
  - Need to hire people with intellectual capacity and interest to advance toward identifiable advancement paths.

Conclusions

- *Availability*: New designs need review for availability, to be confirmed by calculations & by comparable data where possible.
- Both SLAC & DESY plan modular designs with some level of redundancy for high availability (fail-soft).
- *Standards*: Design and construction standards need early agreement.
- *Documentation* is especially crucial in GAN environment & needs strong tools, personnel.

Conclusions

- *Expert Personnel*: Experts except for Maintenance & Safety Teams can operate from off-site.
- A plan is needed for keeping remote experts effectively engaged throughout project phases & personally committed for the long term.
- Recommend occasional expert visits to participate with on-site team along with regular workshops on-site.
- Home institution has responsibility for guaranteeing availability of experts.

Conclusions

- *Project Phases:* All phases can be managed with offsite experts delivering Systems, but effective management needs careful structure and tight lines of responsibility & authority.
- Collaborators need to start work to define effective project management models.

Conclusions

- *Maintenance*: Needs to include onsite engineering level leadership.
- Needs to include software infrastructure maintenance.
- Needs access to key off-site engineering groups through Systems Engineers for setup of routine maintenance, system modifications, system upgrades.

Conclusions

- *Operations*: Conducted from Off-site on 24/7 basis with at least two experts On-Call for each major subsystem.
- WG3 sees no basic reason why remote operations model cannot work.
- Functions may be effectively covered by models similar to present structures.
- WG3 did not estimate numbers required on site. R. Bacher proposed <100 for 24/7 but not discussed in detail.

Conclusions

- Expert Personnel Retention: Labs have had difficulties retaining key personnel when outside job markets are good.
- Extra attention should be paid to developing clear and attractive career paths for all key personnel for all phases from Design through Maintenance & Sustaining Engineering.

Future Collaboration Areas

- Develop Technical management models for all project phases in Collaboration environment.
- Investigate Engineering Documentation & related communications needs & tools.
- Design Standards, Standard modules, Interface standards, high availability designs vs. cost benefit.
- Possible experiments in shared remote control.